

**Dietary Fiber
and its Influence
on Gut Health**

Dietary Fiber and its Influence on Gut Health

It is well known that dietary fiber plays a significant role in preventing non-communicable diseases such as Cardiovascular Disease, Type 2 Diabetes, and certain types of cancers. A lesser known, but emerging fact about dietary fiber is the important role it plays in maintaining our gut health. While the entire gastrointestinal tract encompasses numerous organs, the small and large intestine are of particular interest when evaluating our gut health. The three pillars of gut health include our ability

to properly digest and absorb nutrients from food, the integrity of our gastrointestinal barrier, and the composition of our microbiome. Scientific research focusing on gut health has exploded over the past few decades, and we are beginning to see how our gut health can affect the function of our immune system, our weight, and our risk for intestinal diseases.

Human Digestion and the Gut Microbiota

As humans, we inherently consume food and beverages to sustain life through the extraction of essential nutrients like water, proteins, carbohydrates, and fats during the digestion and absorption mechanisms that occur throughout our body. While these processes begin in our mouth, the bulk of digestion and absorption occurs in our small intestine. When food enters the small intestine, a variety of enzymes work to break down large macronutrients into smaller compounds that can be absorbed for use in a variety of different cellular mechanisms. Food that is not digested or absorbed in the small intestine travels to the large intestine, where it may undergo further breakdown by the bacteria in our gut microbiota.

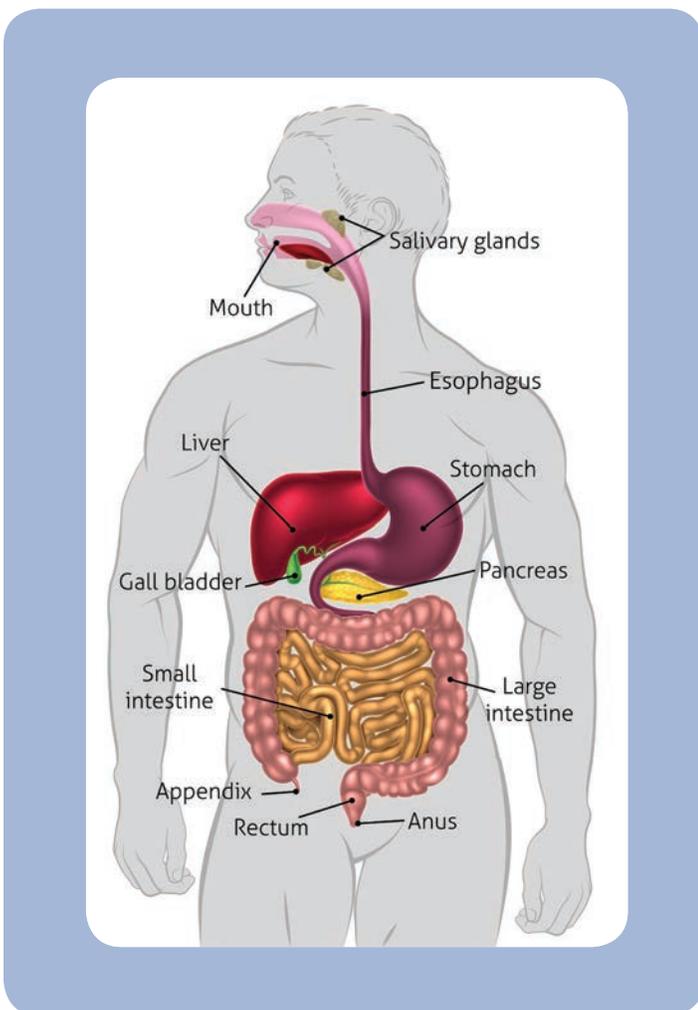


Figure 1: Overview of the human digestive system.

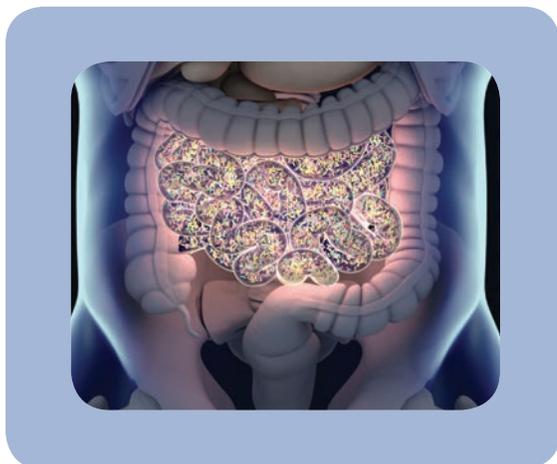


Figure 2: Bacteria, virus, and archaea residents in the human large intestine.

The gut microbiota is an ecosystem of over a thousand different species of bacteria, viruses, and archaea that take up residency in our large intestine. Recent scientific discoveries suggest that the gut microbiome, which includes these microbial species and the metabolites they generate, contributes significantly to our health and well-being.

While there are thousands of different bacterial species that reside in the microbiota, some species are of specific interest because of their unique beneficial effects on our physiology.

The presence of these bacterial species alone and in combination with the thousands of others that reside in our gut yields a diverse microbiome that produces a number of different metabolites.

Bacteria	Effect on host health
<i>Bifidobacterium</i> genus ¹²	Produces short chain fatty acids, improves gut mucosal barrier
<i>Lactobacillus</i> genus ¹²	Produces short chain fatty acids, anti-inflammatory
<i>Roseburia</i> genus ¹²	Produces short chain fatty acids
<i>Ruminococcus bromii</i> ⁸	Produces short chain fatty acids
<i>Eubacterium rectale</i> ¹²	Produces short chain fatty acids

Figure 3: Select beneficial bacterial genera and/or species with their respective functions.

The metabolites produced by specific bacterial species are highly substrate specific, stressing the importance of dietary patterns that provide adequate fuel for the bacteria in our gut. Diets high in animal protein and saturated fat often fail to provide food sources for our beneficial bacteria, and will often promote the growth of pathogenic bacteria that produce toxic bi-products^{12,10}. However, dietary fiber from a plant-based diet that incorporates a variety of whole grains, fruits, and vegetables will provide food sources for multiple beneficial bacterial species in our gut and help keep the population of pathogenic bacteria to a healthy minimum. The unique metabolites produced in response to bacteria consuming dietary fiber can act systemically or locally, and influence the function of our digestive system, immune system, and numerous other metabolic processes.

One group of metabolites generated by the fiber-degrading bacteria in our gut are the short chain fatty acids butyrate, acetate, and propionate². Acetate and propionate may aid in the prevention of a number of chronic diseases such as obesity, Type 2 Diabetes, and Cardiovascular Disease due to their ability to increase fatty acid oxidation, increase glucose uptake into the cells, and lower cholesterol synthesis². Butyrate is particularly important for preventing the development of colon cancer because it provides energy to the colonocytes and has the ability to communicate with the immune system and act as an anti-tumorigenic agent¹¹. Other beneficial metabolites generated by bacteria in response to different dietary compounds include Vitamin K, B vitamins and neurotransmitters, all of which contribute to overall energy production and homeostasis.

The Three Pillars of Gut Health

Antibiotic use, dietary patterns, and various environmental exposures significantly influence the composition of our microbiome. The death of numerous bacterial species in the gut through antibiotic use or inadequate dietary patterns can be detrimental to our health if we do not work to restore the balance of our microbiological ecosystem. The loss of multiple bacterial species decreases our diversity in the gut and puts us at risk for developing infections, gastrointestinal diseases, and losing our ability to generate vitamins and other metabolites in the large intestine. Resistant starch, a type of insoluble dietary fiber, has the ability to positively influence our microbiome and undergo fermentation in our gut to yield beneficial metabolites. Consuming resistant starch may not only increase the population of *Bifidobacterium* in the gut, but it may also increase the levels of *Ruminococcus bromii* and *Eubacterium rectale*; two key species that play pivotal roles in the fermentation and degradation of dietary fiber⁶.

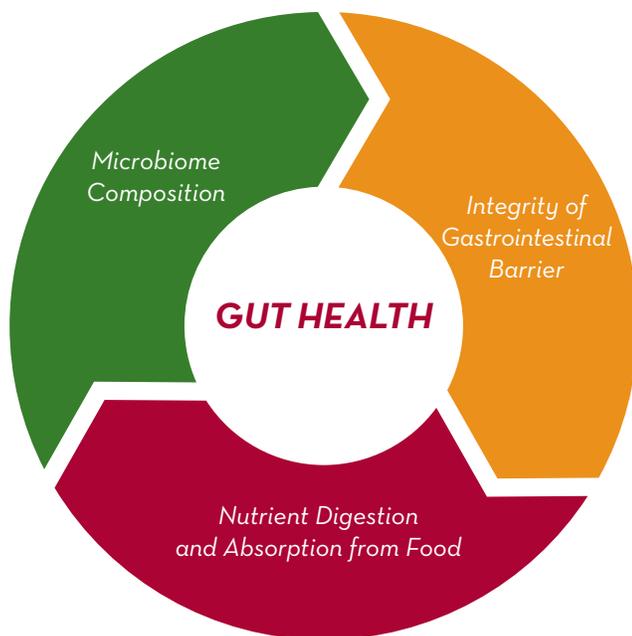


Figure 4: Overview of the three pillars of gut health.

The consumption of whole grains, which contain soluble and insoluble dietary fiber, may enhance bacterial diversity and increase the abundance of important beneficial bacterial genera such as *Roseburia* and *Bifidobacterium*, both of which are important producers of short chain fatty acids⁷. Based on this research, it is clear that the human body and the gut microbiome have an undeniable symbiotic relationship. In order to ensure this symbiotic relationship remains mutualistic, we provide the proper food sources (dietary fiber) that our beneficial bacteria need to flourish.

Mucosal cells joined by tight junctions line the base membrane of our small intestine. Healthy tight junctions between mucosal cells function as a selectively permeable transport system and allow the passage of essential nutrients into the blood for distribution to the cells where they perform their necessary functions. A common pathology increasing within Westernized society is “leaky gut”; a phenomenon in which the tight junctions are compromised, and the protective mucus layer lining the intestinal cells has been damaged, thus allowing for the passage of larger molecules, such as undigested food particles and pathogenic microorganisms, into the blood

stream. The entry of such molecules into the blood stream sets off a massive immune response that can cause issues ranging from chronic low-grade inflammation to the onset of autoimmune disease or food sensitivities. Leaky gut likely plays a role in a number of Westernized diseases such as food allergies/sensitivities, chronic pain, autoimmune disease, Irritable Bowel Syndrome, Inflammatory Bowel Disease, and obesity¹. Diets deficient in dietary fiber degrade the protective mucus layer that lines our intestinal cells and tight

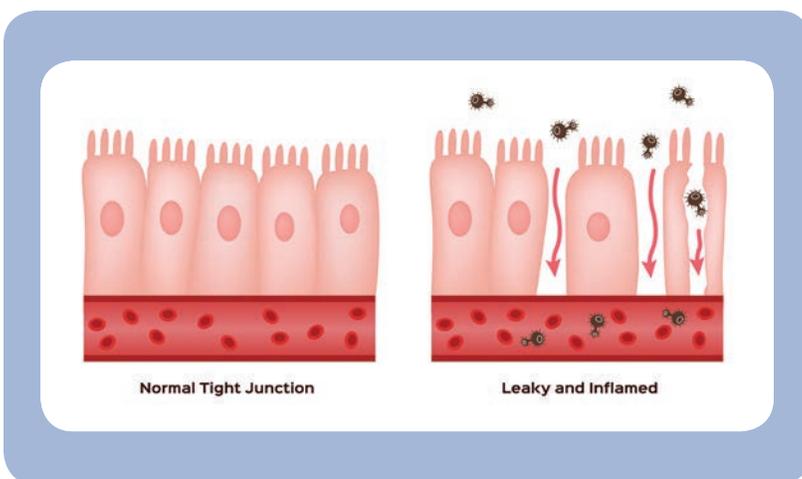


Figure 5: Overview of “leaky gut”.

junctions, thus contributing to leaky gut by allowing pathogens into the blood stream³. However, the consumption of resistant starch and wheat bran fibers can reverse this process by increasing mucus production in the intestinal epithelium of mice⁴. Butyrate, a bi-product of dietary fiber fermentation, can also strengthen the intestinal barrier because of its ability to regulate tight junction proteins⁹. The overwhelming complexity of leaky gut poses significant challenges for its prevention and treatment, but both interventions should ensure an adequate amount of dietary fiber consumption, as it may help strengthen tight junctions and preserve our thick, protective mucus layer.

Nutrient deficiencies, medication overuse, and dietary fiber intake all affect our ability to digest and absorb food effectively. Poor dietary choices and nutritional inadequacies will contribute to digestive irregularities like constipation and diarrhea, two conditions that have plagued societies worldwide. Consuming fermentable dietary fiber sources help restore balance by promoting bacterial diversity and enhancing mineral absorption⁵. The fermentation of dietary fiber sources like resistant starch, commonly found in whole grains, whole seeds, high amylose grains, and cooked/cooled starchy foods yields short chain fatty acids that lower the pH of our large intestine and allow for optimal mineral absorption. In addition, the incorporation of dietary fiber into your diet can also help standardize digestion through its ability to regulate transit time. A common recommendation for those suffering from chronic constipation is to increase consumption of insoluble fiber, as it can help bulk up your stool and speed up transit time. Conversely, recommendations for those suffering from diarrhea often include the consumption of soluble dietary fiber because it helps slow down your overall transit time. Because of this notable characteristic, soluble fiber also allows for enhanced satiety and a slower, more regulated release of nutrients into the intestinal lumen.



Figure 6: Food sources that contribute to dietary fiber consumption.

How Can I Get More Fiber?

A diet deficient in dietary fiber, a common occurrence observed in Westernized societies, has grave implications for the health of our gut. Even though the research is still in its infancy, there is strong evidence to show that the composition of our microbiome, the integrity of our tight junctions, and our digestion and absorptive mechanisms play a key role in preventing disease and maintaining our health. Embracing a plant based diet and incorporating more flavorful whole grains, fruits, and vegetables into our daily routine is a simple way to increase dietary fiber consumption and keep our gut happy and healthy! Bay State Milling Company is a leading supplier of plant-based, whole food ingredients that can be incorporated into any plant-based diet. To learn more about our plant-based ingredient solutions, including HealthSense High Fiber Wheat Flour, please contact Bay State Milling Company.

References:

1. Bischoff, S. C., Barbara, G., Buurman, W., Ockhuizen, T., Schulzke, J. D., Serino, M., ... Wells, J. M. (2014). Intestinal permeability--a new target for disease prevention and therapy. *BMC Gastroenterol*, 14, 189. doi:10.1186/s12876-014-0189-7
2. den Besten, G., van Eunen, K., Groen, A. K., Venema, K., Reijngoud, D. J., & Bakker, B. M. (2013). The role of short-chain fatty acids in the interplay between diet, gut microbiota, and host energy metabolism. *J Lipid Res*, 54(9), 2325-2340. doi:10.1194/jlr.R036012
3. Desai, M. S., Seekatz, A. M., Koropatkin, N. M., Kamada, N., Hickey, C. A., Wolter, M., . . . Martens, E. C. (2016). A Dietary Fiber-Deprived Gut Microbiota Degrades the Colonic Mucus Barrier and Enhances Pathogen Susceptibility. *Cell*, 167(5), 1339-1353.e1321. doi:10.1016/j.cell.2016.10.043
4. Jimenez, J. A., Uwiera, T. C., Abbott, D. W., Uwiera, R. R. E., & Inglis, G. D. (2016). Impacts of resistant starch and wheat bran consumption on enteric inflammation in relation to colonic bacterial community structures and short-chain fatty acid concentrations in mice. *Gut Pathog*, 8, 67. doi:10.1186/s13099-016-0149-6
5. Lattimer, J. M., & Haub, M. D. (2010). Effects of dietary fiber and its components on metabolic health. *Nutrients*, 2(12), 1266-1289. doi:10.3390/nu2121266
6. Martínez, I., Kim, J., Duffy, P. R., Schlegel, V. L., & Walter, J. (2010). Resistant Starches Types 2 and 4 Have Differential Effects on the Composition of the Fecal Microbiota in Human Subjects. *PLoS One*, 5(11), e15046. doi:10.1371/journal.pone.0015046
7. Martínez, I., Lattimer, J. M., Hubach, K. L., Case, J. A., Yang, J., Weber, C. G., . . . Walter, J. (2013). Gut microbiome composition is linked to whole grain-induced immunological improvements. *The ISME journal*, 7(2), 269-280. doi:10.1038/ismej.2012.104
8. Morrison, D. J., & Preston, T. (2016). Formation of short chain fatty acids by the gut microbiota and their impact on human metabolism. *Gut Microbes*, 7(3), 189-200. doi:10.1080/19490976.2015.1134082
9. Peng, L., Li, Z.-R., Green, R. S., Holzman, I. R., & Lin, J. (2009). Butyrate Enhances the Intestinal Barrier by Facilitating Tight Junction Assembly via Activation of AMP-Activated Protein Kinase in Caco-2 Cell Monolayers. *The Journal of nutrition*, 139(9), 1619-1625. doi:10.3945/jn.109.104638
10. Rooks, M. G., & Garrett, W. S. (2016). Gut microbiota, metabolites and host immunity. *Nat Rev Immunol*, 16(6), 341-352. doi:10.1038/nri.2016.42
11. Siavoshian, S., Segain, J. P., Kornprobst, M., Bonnet, C., Cherbut, C., Galmiche, J. P., & Blottiere, H. M. (2000). Butyrate and trichostatin A effects on the proliferation/differentiation of human intestinal epithelial cells: induction of cyclin D3 and p21 expression. *Gut*, 46(4), 507-514.
12. Singh, R. K., Chang, H. W., Yan, D., Lee, K. M., Ucmak, D., Wong, K., . . . Liao, W. (2017). Influence of diet on the gut microbiome and implications for human health. *J Transl Med*, 15(1), 73. doi:10.1186/s12967-017-1175-y